Fact sheet: Pork production with immunocastrates

Background: Surgical castration of male piglets is mainly carried out without any pain relief and therefore presents a welfare problem which has been facing increasing criticism. Already in 2010 a number of European stakeholders committed to end surgical castration by 2018, providing that satisfactory solutions are found to the various challenges associated with the production of entire male pigs. Entire male pigs have the advantage of a higher anabolic potential than barrows, which leads to a better feed conversion rate, lower N-excretion and a higher meat percentage of the carcass. However, the risk of boar taint, the main quality problem in pork production with entire males, has not been solved reliably. The main boar taint compounds androstenone and skatole are lipophilic and may accumulate in fat of growing boars until slaughter due to the progress in pubertal development. Furthermore, some boar specific welfare problems related to sexual behaviour and aggressions (e.g. injuries, lameness) may occur. In addition, some quality issues of boar meat and fat reduce their suitability for processing especially in the case of high quality dry meat products. Therefore there is an increasing interest and a need for animal friendly and reliable approaches for improving product quality. One of these approaches is immunocastration. Immunocastration can be carried out with Improvac® from Zoetis and Valora® from Ceva, the second one not approved in Europe. Most of information about the effect of immunocastration in carcass and meat quality come from studies carried out with Improvac®, thus, the present fact sheet refers to this vaccine.

Immunocastration, an alternative to surgical castration: Immunocastration, a vaccination with Improvac® is an active immunization against GnRH, a key hormone of the endocrine cascade regulating testicular functions. To induce antibodies against GnRH two consecutive vaccinations are carried out in at least a 4 weeks interval. The antibodies bind endogenous GnRH suppressing the testicular functions for at least 10 weeks (Thompson, 2000) which may resume thereafter (Claus et al., 2008; Einarsson et al., 2009). The first vaccination has only minor consequences for the number of GnRH antibodies. The endocrine system, growth performance or the behavior of immunocastrates are boar-like until the second vaccination. Thereafter they become more comparable to barrows in all traits. Accordingly, the boar taint can be reliably suppressed by immunocastration if the second vaccination is carried out about 4 to 6 weeks before slaughter (Batorek et al., 2012a; Poulsen Nautrup et al., 2018). A major benefit of immunocastration is preventing both, the pain associated with the surgical castration and the risk of wound infection.. Thus, the incidences of morbidity and mortalities due to post surgical complications can be reduced (Morales et al., 2017). Immunocastation is also effective in cryptorchids and allows to avoid more sophisticated surgical procedures or a higher risk of boar taint in these animals (Gutzwiller & Ampuero Kragten, 2013)

Challenges in pork production with immunocastrates: Acceptance of immunocastration depends on the food safety for the consumer. The safety for consumers and the reliability of the vaccine are well documented. As part of the European Medicines Agency approval process for Improvac®, food safety was evaluated and several studies tested hormonal and oral efficacy of the synthetic antigen used in the vaccine (EMA, 2010). GnRH itself has no immunogenic effect and does not stimulate antibody

production. The synthetic vaccine consists of a truncated GnRH (AS 2-10) conjugated to a diphtheria toxoid and adsorbed to DEAE-dextran (Patent US 8,741.303B2). The antigenic fragment itself has only a potency of 0.2% on the release of luteinizing hormone when compared to injections of the decapeptide (AS 1-10; Clarke et al., 2008) as the missing amino acid is involved in receptor binding (Dorn & Griesinger, 2009). The diphteria toxoid has already been used for other vaccines and has been shown to have no toxic effect on hormonal activity (EMA, 2010). As with all vaccinations, at extremely rare occasions (1 in 10^6), a severe allergic reaction may happen within a few minutes of the vaccination in the animal. Adverse reactions in pigs are minimized if the vaccine is applied according to the manufactures recommendation (subcutaneous injections at the base of the ear) by trained persons. The oral effects of the vaccine were tested in pigs and rats and did not influence testicular functions (Clarke et al., 2008). It was therefore concluded that the vaccine is not orally effective and the withdrawal time was set at 0 days before slaughter (EMA, 2017).
The main risk for the operator is a potential self-injection of the vaccine. In the scientific report of the European Medicines Agency (EMA; 2010) the risk of self-injections is estimated at 0.00004%. However, in order to minimize the risk of self-injections, the manufacturer of Improvac® provides a safety device for vaccination (European Commission, 2019). Nevertheless, the consequences of a potential self-injection have to be estimated. GnRH is crucial for reproduction and no species differences in GnRH amino acid sequence exist between pigs and humans (D'Occhio, 1998). Vaccination against GnRH would therefore lead to transient infertility in humans, both females and males. After an accidental self-vaccination, the user must not carry out further vaccinations to avoid high GnRH antibody production when a second accidental self-injection would be applied. In a study by Simms and co-authors (2000) with prostate cancer patients, GnRH vaccination was tested to suppress testosterone-induced tumor growth in 12 patients with advanced prostate cancer. In five patients, a significant decrease in testosterone concentrations was shown. The suppression of testicular function was transient and testosterone returned to normal concentrations after 9 months.

Management consequences of pork production with immunocastrates: For successful immunocastration, the available vaccine in Europe(Improvac®) has to be performed at least twice. Like for any other vaccination only healthy animals are suitable. Even if the first vaccination could be applied at 8-9 weeks of age (Čandek-Potokar et al., 2017), such an early vaccination may not be recommended if piglets are sold and not raised on the same farm where they have been born, as the vaccination cannot be controlled and a 100% vaccination rate is required to avoid behavioral and quality problems. Therefore, the first vaccination is usually carried out early in the fattening period at about 12 weeks of age. It has only minor effects on the testicular hormone production and the animals are metabolically boars before the second vaccination. The second vaccination should be applied at least 4 weeks and maxium 10 weeks after the first one and leads to a drop in testosterone and estradiol concentrations within a week followed by a switch from the male pattern of feed intake, metabolism and behavior to that of barrows with a further delay of about one week. The recommended time between the second vaccination and slaughter is about 4 to 5 weeks to allow release of already accumulated boar taint compounds from adipose tissue. Even if long term studies revealed a resumption of testicular function after 10 to 24 weeks (Claus et al., 2008), a third vaccination is suggested if animals are slaughtered at a higher age, such as in organic farming or some autochthonous breeds. A third vaccination is also recommended if male behavior does not decrease within two weeks after the second vaccination, to avoid possible non responders. Immunocastrates show less aggressive and mounting behavior than boars (Rydhmer et al., 2006; Reiter et al., 2017), hence less problems with lameness and other skeletal problems due to the

mounting in both, aggressor and the mounted animal (Rydhmer et al., 2006). Additionally, penile injuries may be caused in case of sexually oriented mounting by penis biting after extrusion of the penis. A high incidence of penile injuries, which increase with age, has been described for domestic and wild boars (Weiler et al., 2016; Reiter et al., 2017). Immunocastration reduces the frequency and severity of penile injuries (Reiter et al., 2017). This effect is more pronounced, if animals are vaccinated early (V1/V2 at 8/12 weeks of age: 16.7% injuries) in comparison to V1/V2 at 12/18 weeks of age (41.7% injuries; Reiter et al., 2018). However, restrictive feeding after the second vaccination, can lead to more aggressive behavior and higher incidences of skin lesions in immunocastrates as voluntary feed intake increases considerably with meal size increasing by 25%. Thus aggressive behavior and incidences of skin lesions may increase comparable to the level among entire males (Batorek et al., 2012b).

The timing of the second vaccination is a tool to tailor the production according to the demands of market and productivity. After the 2nd vaccination immunocastrated pigs have higher average daily gain rates than boars, but feed conversion rate is favourable (Batorek et al, 2012a; Weiler et al, 2013). Accordingly, the animals get fatter as the anabolic effects diminish (Čandek-Potokar et al., 2017). On the other hand, a meta-analysis which included 78 studies by Poulsen Nautrup et al. (2018) showed that immunocastrates are more efficient in gain ratios and carcass yields than boars and barrows. Compared to barrows, immunocastrates have significantly higher daily average gains of 26.30 g/day over the entire fattening period and the feed utilization of the immunocastrates is improved by -0.223 kg feed/kg. Compared to boars, immunocastrates have a higher daily gain of 59.4 g/day but a worse feed utilization of 0.072 kg feed/kg gain (Poulsen Nautrup et al, 2018). This meta-analysis and another one by Batorek et al. (2012a) also showed that there are quality differences between boars, immunocastrates and barrows. The lean meat content of the carcasses is the highest in boars, followed by immunocastrates and barrows. In particular, the weights of the ham and shoulder are significantly higher in boars and immunocastrates than in barrows. The meat quality of immunocastrates becomes comparable to that of barrows as the intramuscular fat increases while the boar taint compounds are cleared before slaughter. Both, immunocastrates and barrows, have more saturated fatty acids which are better for processing purposes (Čandek-Potokar et al., 2017). This factor is particularly important in the production of traditional ham products, since this is accompanied by a long maturation period (Poulsen Nautrup et al, 2018; Bonneau et al., 2018).

Another criterion for being successful in the market is the reliability and efficacy of the method. Several reviews (Zamaratskaia and Rasmussen, 2015; Čandek-Potokar et al., 2017; Škrlep et al., 2014) have already described the phenomenon of non-responders. It is mentioned that on average, 0-3% of pigs were not successfully immunocastrated. The reasons stated were that, these animals, might have been accidentally missed during vaccination or might have had a suppressed immune system due to health problems at time of vaccination. The meta-analyses by Batorek et al. (2012a) and Poulsen Nautrup et al. (2018) show that immunocastration prevents boar taint very well and is a reliable method. It seems, that if the vaccine is handled properly, the vaccine is stored correctly and the manufacturer's vaccination recommendations are met, almost 100% of the vaccinated animals produce sufficient antibodies and react accordingly. Whether or not immunocastrates should be checked at slaughter line for boar taint is a corporate risk decision. With an assumed proportion of non-responders of 3% and a rate of boar-tainted carcasses within boars of 10 to 30%, the risk of tainted carcasses of immunocastrates is 0.3 to 0.9% (Čandek-Potokar et al., 2017). Assuming that reproducibility of the currently used human nose test at slaughter line of 23%, this value is far below the currently marketed off-odoured carcasses of boars (Mathur et al., 2013).

Immunocastration can also be used for alternative production systems where animals are fattened longer, partly in free ranging systems with potential contact to wild boars and slaughtered at older ages. In order to prevent unwanted pregnancies during the fattening period, the females are surgically castrated in these systems as well. The use of immunocastration allows to omit surgical castration (Dalmau et al., 2015). Moreover the meat quality from immunocastrated females was unaffected (Martinez-Macipe et a., 2015). So animal welfare could also be increased with immunocastration in traditional or free ranging production systems.

Immunocastration could also have positive effects on organic pig production. In the study by Grela et al. (2013), boars, immunocastrates, barrows and gilts were fattened under organic conditions. Growth performance as well as feed conversion ratio and lean meat content were higher in immunocastrates and boars than in barrows or gilts. Immunocastration was evaluated positively both from production perspective as well as meat quality perspective. In organic production systems, it only needs to be taken into account that for longer periods of fattening or mixed-sex fattening, the animals should be vaccinated earlier and, if necessary, vaccinated a third time, in order to prevent unwanted pregnancies and boar taint.

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